

## CLAIMS

1. Multi-user detection method with elimination of interference between users, each user transmitting modulated data in the form of symbols on a transmission channel, each transmission channel ( $k$ ) comprising at least one propagation path ( $i$ ) and each propagation path arriving at an array of reception antennae ( $\ell$ ) according to a direction of arrival ( $\theta_{i,k}$ ), the method comprising at least one sequence of steps for each user ( $k$ ), characterised in that each sequence comprises:

(a) a reception step (600<sub>k</sub>, 700<sub>k</sub>, 800<sub>k</sub>, 800, 900) decomposing each antenna signal into filtered signals ( $x_{\ell,i,k}$ ) issuing from the different paths ( $i$ ) of the said user ( $k$ ) and combining the said filtered signals by means of a first plurality of coefficients ( $b_{\ell,i,k}$ ,  $c_{i,k}$ ) in order to form an estimation ( $z_k$ ) of the signal transmitted by the user;

(b) a step of estimating (670<sub>k</sub>, 770<sub>k</sub>, 870<sub>k</sub>, 870, 970) the contribution ( $(x_{\ell,k}) \ell=1..L$ ) of the user to the signals received by the different antennae from the said estimation of the signal transmitted and a second plurality of coefficients ( $u_{i,k}$ ,  $w_{\ell,i,k}$ ) obtained from the said first plurality of coefficients;

(c) a step of eliminating interference (680<sub>k</sub>, 780<sub>k</sub>, 880<sub>k</sub>, 880, 980) subtracting from the antenna signals the contribution estimated at step (b) in order to obtain cleaned antenna signals;

the cleaned antenna signals supplied by at least one first sequence being used as antenna signals by at least one second sequence.

2. Multi-user detection method according to Claim 1, characterised in that the first plurality of coefficients comprises a first set of complex coefficients ( $b_{\ell,i,k}$ ) and a second set of complex coefficients ( $c_{i,k}$ ) and in that the filtered signals ( $x_{\ell,i,k}$ ) are subjected to a channel formation step (420<sub>k</sub>) in order to form signals of paths ( $y_{i,k}$ ) by means of the said first set, the said path signals then being linearly combined (440<sub>k</sub>) by means of the said second set in order to supply the said estimation ( $z_k$ ) of the signal transmitted, the coefficients of the first set being adapted so as to minimise a plurality of first error signals ( $\varepsilon_{i,k}$ ) between a reference value ( $q_k$ ) of the transmitted signal and the said path signals ( $y_{i,k}$ ), the coefficients of the said second

set being adapted so as to minimise a second error signal ( $\varepsilon''_k$ ) between the said estimation ( $z_k$ ) and the said reference value.

3. Multi-user detection method according to Claim 2, characterised in that the  
 5 said second plurality ( $w_{\ell,i,k}, u_{i,k}$ ) of coefficients comprises a first set of complex coefficients ( $w_{\ell,i,k}$ ) and a second set of complex coefficients ( $u_{i,k}$ ), the coefficients ( $w_{\ell,i,k}$ ) of the said first set of the second plurality being obtained from the arguments of the coefficients ( $b_{\ell,i,k}$ ) of the first set of the first plurality and the coefficients ( $u_{i,k}$ ) of the said second set of the second plurality being obtained from coefficients ( $c_{i,k}$ ) of  
 10 the said second set of the first plurality.

4. Multi-user detection method according to Claim 3, characterised in that the  
 coefficients ( $u_{i,k}$ ) of the said second set of the second plurality are obtained by  
 conjugation of the coefficients ( $c_{i,k}$ ) of the second set of the first plurality.

5. Multi-user detection method according to Claim 3 or 4, characterised in that  
 the coefficients ( $w_{\ell,i,k}$ ) of the said first set of the second plurality are obtained from a  
 linear regression on the arguments of the coefficients ( $b_{\ell,i,k}$ ) of the first set of the first  
 plurality.

6. Multi-user detection method according to one of Claims 2 to 5, characterised  
 in that, at the first sequence,

the coefficients ( $b_{\ell,i,k}$ ) of the first set of the first plurality are initialised by  
 $b_{\ell,i,k}(0) = \delta(\ell - \ell_0), \forall i$  where  $\delta$  is the Dirac symbol,  $\ell_0$  is an antenna number;

25 and in that the coefficients ( $c_{i,k}$ ) of the second set of the first plurality are  
 initialised by  $c_{i,k}(0) = c, \forall i$  where  $c$  is a given complex coefficient.

7. Multi-user detection method according to one of Claims 2 to 5, characterised  
 in that, at the first sequence, the coefficients ( $b_{\ell,i,k}$ ) of the first set of the first plurality  
 30 are initialised by  $b_{\ell,i,k}(0) = \exp(-j(\hat{v}_{i,k}(0) + 2\pi d/\lambda \cos \hat{\theta}_{i,k}(0) \cdot (\ell - 1)))$   
 and in that the coefficients ( $c_{i,k}$ ) of the second set of the first plurality are initialised  
 by  $c_{i,k}(0) = \hat{\alpha}_{i,k}(0)$  where  $\hat{\theta}_{i,k}(0)$ ,  $\hat{v}_{i,k}(0)$ ,  $\hat{\alpha}_{i,k}(0)$  are respectively estimations of the  
 directions of arrival, phase rotations and coefficients of attenuation for the different  
 paths.

8. Multi-user detection method according to Claim 1, characterised in that the first plurality of coefficients consist of a set of complex coefficients  $(b_{\ell,i,k})$  and in that the filtered signals  $(x_{\ell,i,k})$  are linearly combined  $(520_k)$  by means of said set in order to supply said estimation  $(z_k)$  of the signal transmitted, the coefficients of said set being adapted so as to minimise an error signal  $(\varepsilon_k)$  between the said estimation  $(z_k)$  and a reference value  $(q_k)$ .

9. Multi-user detection method according to Claim 8, characterised in that the said second plurality  $(w_{\ell,i,k}, u_{i,k})$  of coefficients comprises a first set of complex coefficients  $(w_{\ell,i,k})$  and a second set of complex coefficients  $(u_{i,k})$ , the coefficients  $(u_{i,k})$  of the said second set of the second plurality being obtained by:  $u_{i,k} = g_{i,k} / g_k$

where  $g_{i,k}$  is an estimation of the norm of the sub-vector  $\bar{\mathbf{b}}_{i,k} = \begin{pmatrix} b_{1,i,k} \\ b_{2,i,k} \\ \vdots \\ b_{L,i,k} \end{pmatrix}$ , L being the

number of antennae in the array, where  $g_k$  is a mean of the  $g_{i,k}$  values on the different paths, the coefficients  $(w_{\ell,i,k})$  of the said first set of the second plurality being obtained from the arguments of the coefficients  $(b_{\ell,i,k})$  of the said set of the first plurality.

10. Multi-user detection method according to Claim 8 or 9, characterised in that, at the first sequence, the coefficients  $(b_{\ell,i,k})$  of the said set of the first plurality are initialised by  $b_{\ell,i,k}(0) = b \cdot \delta(\ell - \ell_0), \forall i$  where  $\delta$  is the Dirac symbol,  $\ell_0$  is an antenna number and  $b$  a given complex coefficient.

11. Multi-user detection method according to Claim 8 or 9, characterised in that, at the first sequence, the coefficients  $(b_{\ell,i,k})$  of the said set of the first plurality are initialised by  $b_{\ell,i,k}(0) = \hat{\alpha}_{i,k}(0) \cdot \exp(-j(\hat{\nu}_{i,k}(0) + 2\pi d / \lambda \cdot \cos \hat{\theta}_{i,k}(0) \cdot (\ell - 1)))$  where  $\hat{\theta}_{i,k}(0)$ ,  $\hat{\nu}_{i,k}(0)$ ,  $\hat{\alpha}_{i,k}(0)$  are respectively estimations of the directions of arrival, phase rotations and coefficients of attenuation for the different paths.

12. Multi-user detection method according to one of the preceding claims, characterised in that, for a given user  $(k)$ , the interference is eliminated by subtracting  $(680_k, 880_k, 880, 980)$  from the antenna signals of the contributions of all the other users.

13. Multi-user detection method according to Claim 12, characterised in that each sequence comprises a step of estimating (610<sub>k</sub>, 710<sub>k</sub>, 810<sub>k</sub>, 810,910) the symbols transmitted from the estimation of the signal transmitted ( $z_k$ ) in order to obtain first estimated signals ( $\hat{s}_k$ ), a step of demodulating (620<sub>k</sub>, 720<sub>k</sub>, 820<sub>k</sub>, 820,920) the first estimated symbols ( $\hat{s}_k$ ) in order to obtain estimated data ( $\hat{d}_k$ ), a step of channel decoding (630<sub>k</sub>, 730<sub>k</sub>, 830<sub>k</sub>, 830,930) of the said estimated data followed by a channel recoding (640<sub>k</sub>, 740<sub>k</sub>, 840<sub>k</sub>, 840,940) and a remodulation (650<sub>k</sub>, 750<sub>k</sub>, 850<sub>k</sub>, 850,950) in order to obtain second estimated symbols ( $\hat{s}'_k$ ).

14. Multi-user detection method according to Claim 2 or 13, or 8 and 13, characterised in that the reference value ( $q^{(n)}_k$ ) for a transmitted signal, used at the second sequence or at a subsequent sequence ( $n$ ), is the second estimated symbol ( $\hat{s}^{(n-1)}_k$ ) obtained for this signal at the previous sequence.

15. Multi-user detection method according to Claim 2 or 14, or 8 and 14, characterised in that the reference value ( $q^{(n)}_k$ ) for a transmitted signal, used at the second sequence or at a subsequent sequence ( $n$ ), is a combination of the first estimated symbol ( $\hat{s}^{(n)}_k$ ) obtained for this signal at the current sequence and of the second estimated symbol ( $\hat{s}^{(n-1)}_k$ ) obtained for this signal at the previous sequence.

16. Multi-user detection method according to one of the preceding claims, characterised in that, at the second sequence and at the subsequent sequences, the coefficients of the first plurality of a sequence are initialised from the values of coefficients of the first plurality of the previous sequence.

17. Multi-user detection method according to one of Claims 1 to 11, characterised in that the users are classified in order of received power and in that the interference is eliminated by subtracting (780<sub>k</sub>), one after the other, the contributions of the different users, commencing with the users with the highest received powers.

18. Multi-user detection method according to Claims 6 and 17, characterised in that, for each sequence of a user ( $k$ ), the coefficients ( $b_{i,k}$ ) of the first set of the first

plurality are initialised by  $b_{\ell,i,k}(0)=\delta(\ell-\ell_0), \forall i$  where  $\delta$  is the Dirac symbol,  $\ell_0$  is an antenna number;

and in that the coefficients  $(c_{i,k})$  of the second set of the first plurality are initialised by  $c_{i,k}(0)=c, \forall i$  where  $c$  is a given complex coefficient.

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19. Multi-user detection method according to Claims 7 and 17, characterised in that, for each sequence of a user  $(k)$ , the coefficients  $(b_{\ell,i,k})$  of the first set of the first plurality are initialised by  $b_{\ell,i,k}(0)=\exp(-j(\hat{\nu}_{i,k}(0)+2\pi d/\lambda \cos \hat{\theta}_{i,k}(0).(\ell-1)))$

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and in that the coefficients  $(c_{i,k})$  of the second set of the first plurality are initialised by  $c_{i,k}(0)=\hat{\alpha}_{i,k}(0)$  where  $\hat{\theta}_{i,k}(0)$ ,  $\hat{\nu}_{i,k}(0)$ ,  $\hat{\alpha}_{i,k}(0)$  are respectively estimations of the directions of arrival, phase rotations and coefficients of attenuation for the different paths.

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20. Multi-user detection method according to Claims 10 and 17, characterised in that, for each sequence of a user  $(k)$ , the coefficients  $(b_{\ell,i,k})$  of the said set of the first plurality are initialised by  $b_{\ell,i,k}(0)=b \cdot \delta(\ell-\ell_0), \forall i$  where  $\delta$  is the Dirac symbol,  $\ell_0$  is an antenna number and  $b$  a given complex coefficient.

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21. Multi-user detection method according to Claims 11 and 17, characterised in that, for each sequence of a user  $(k)$ , the coefficients  $(b_{\ell,i,k})$  of the said set of the first plurality are initialised by  $b_{\ell,i,k}(0)=\hat{\alpha}_{i,k}(0) \cdot \exp(-j(\hat{\nu}_{i,k}(0)+2\pi d/\lambda \cos \hat{\theta}_{i,k}(0).(\ell-1)))$  where  $\hat{\theta}_{i,k}(0)$ ,  $\hat{\nu}_{i,k}(0)$ ,  $\hat{\alpha}_{i,k}(0)$  are respectively estimations of the directions of arrival, phase rotations and coefficients of attenuation for the different paths.

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22. Multi-user detection method according to Claim 12, characterised in that, the estimations of the transmitted signals of the users being considered to be an estimations vector with  $K$  components where  $K$  is the number of users, the said vector is subjected to a transverse matrix filtering (805,905).

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23. Multi-user detection method according to Claim 22, characterised in that, the estimated symbols of the users being considered to be a symbols vector with  $K$  components, the said symbols vector is subjected to a postcursor matrix filtering (907) and the output of this filtering is subtracted, vector by vector, from the output of the transverse matrix filtering (905).

24. Multi-user detection device, characterised in that it comprises means adapted to implement the method according to one of the preceding claims.

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